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Advantages of Mechanical Concrete Road Over Conventional Road

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Abstract*— Mechanical Concrete is unicellular confined aggregate unit, it binds aggregates into a singular confinement to support lateral soil pressure, also binds aggregates tighter into a load bearing cell. It basically supports the aggregates used in conventional road, confining it into a single cellular structure. The cellular structure of the mechanical concrete confines the stones used as aggregates. The confinement can be tire derived or any hollow cylindrical confinement, the paper mostly emphasizes on the cost effectiveness of the road also enhancing its strength and durability hence recycled tires are used in Mechanical Concrete Road. Mechanical concrete is a thin walled cylinder of uniform circular shape made up of a single material that is plastic or rubber. The paper consists of the test results and analysis using rubber as a binding cylinder. Mechanical concrete can be manufactured from any suitable material having sufficient tensile and proper size to resist the lateral pressure exerted on it when the aggregates are placed under load. Here the preference is given to any recycled auto or truck tire having its side walls removed. Hence the tire used does not bear the properties of the tire but through manufacturing becomes Tire-Derived cylinder.

***Index Terms*—Confined Aggregates, Conventional road, Reuse of waste tires, tire derived cylinders.**

I. INTRODUCTION

The paper introduces a revolutionary change in laying of conventional road, thus focusing on the design parameters and cost effectiveness of the MCR over conventional roads. Mechanical concrete is a material manufactured by using cylinder to confine the stone aggregates to achieve optimum load bearing strength .The Paper aptly compares the advantages of MCR over the conventional road designs. It depicts the use and the test carried on four different material used as fillers in the manufacturing of the MCR. This combination of aggregates and the confinement gives a strong unit cellular structure of MCR. This cellular structure has becomes a unit building block of the MCR. This cell may also be addressed as geo-synthetic cell. It has strength equal to that of a concrete block hence the name Mechanical Concrete. The aggregates used as filler material in MCR are tested profoundly for its shear strength and crushing value. The stone aggregates used in MCR have varied sizes and texture. MCR requires no compaction hence has an edge over the manufacturing of the conventional roads. The vertical loads applied on the geo-synthetic cylinder distribute the lateral moving loads to achieve its strength.

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Most roadways failures are due to extensive lateral pressure distributed unevenly due to unconfinement of aggregates used in conventional roads. Hence in MCR the use of geo-cells confine the aggregates distributing the vertical loads preventing pothole formation due to lateral failure of the aggregates.

Objectives –

- To achieve economy in manufacturing of roads using recycled materials.
- To mitigate the cost of maintenance.
- Environmentally viable, green technology.
- Use of simple technology with minimum time for construction of road.

Fig. 1 – Confined Aggregates (CA)

II. METHODOLOGY

The site should be prepared to receive the tire-derived-cylinders, TDC, by removing surface materials to the required depth. TDC is laid on the sub-grade layer of the road such that each cylinder is in contact with at least three adjacent cylinders. The use of tire-derived cylinders in the manufacturing of the mechanical concrete road comprises of laying geo-cells in grid formation connected to each other by rivets or binding wire. The simplest way is to use a nail gun to drive a nail through adjacent cylinders where they come in contact. Due to uneven tire diameters the circular shape of the CA is not always achieved however, the placing of the CA should be in such a way that it should not squash the adjacent TDC into oval shape. To maintain the geometric integrity of the circular shape of the TDC the filling of the CA is done when the TDC is in contact with three cylinders. This implies that the TDC should be in contact with at least three cylinders. While filling the TDC with front end bulldozer there pose a serious problem of collapse of side walls of the adjacent cylinder. The aggregates are poured over the cylinder without compaction of the materials used in MCR which helps in maintaining the void ratio providing water to drain off easily, leading to heavy reduction in maintenance of roads.

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Mechanical concrete roads exhibits exceptional strength to lateral pressure confining the aggregates thereby reducing the cost of maintenance and repair work. The labors used in manufacturing of mechanical concrete roads are unskilled labors hence the construction cost and repair works of MCR is minimum as compared to that of conventional roads.

Fig. 2 – Laying of Mechanical Concrete Road (MCR)

III. MATERIALS

The tire derived cylinder is a thin wall circular, cylindrical segment of a specific suitable material having load bearing capacity more than the circular tensile forces resulting from the lateral soil pressure caused due to the self weight of the aggregates (stones) and the live loads superimposed by vehicle. The motive is sufficed by removing the side walls of the automotive tire. The tire tread cylindrical diameter shall not be more than 0.71m and not less than 0.61m. The tire tread cylinder width shall not be less than 0.17m and should not be more than 0.22m. The tire should be of uniform diameter and tread width have no internal steel for fiber belts exposed in the tread surface.

IV. GEO-CELLS

In geo-synthetic cell (TDC), the collection of similar sized same types of aggregates , behaves like a thick hydraulic fluid of pure compressive nature. Except for the friction between them the particle have little or no lateral tensile strength and thus low like fluid in under compressive forces. The Aggregates transfer the main supported load downwards along the axis of the cylinder to the earth and also transfer the transverse lateral pressure to the cylinder device which then resist the hoop stress. The green heart of this technology is the tire-derived-geo-cylinder which confines and strengthens the stone aggregates Tire-Derived Geo-Cylinders (TDC) is introduced and is tested for loads greater than HS 20 wheel loads. As the name suggests the TDC is made of tires acting as cylindrical confinement giving lateral support to the stone aggregates and thus enhancing its load bearing capacity and uses. The reuse of discarded ,tread worn, automotive tires with both sidewalls removed ,is assessed and recommended for its use as the confining cylinder for the TDC. The tire derived cylinder performs functions similar to that of a cement and thus acts as a binder by confining the aggregates used as fillers in it.

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V. COMPARISON OF MECHANICAL CONCRETE ROAD AND CONVENTIONAL ROAD

Mechanical concrete roads has varied advantages over the use of Conventional roads in regards with the time, cost and materials required for construction of roads

- **Time Comparison**
  The time required for the construction of MCR is comparatively less than that for conventional roads. Following analysis of activities in table 1, and graphically represented by graph 1.The activity chart depicts the difference in the time for completion of different activities in construction of a mechanical concrete road and that of conventional road
- **Material Comparison**
  There is reduction in the material requirement for MCR because compaction is not required for the laying of aggregates in MCR due to confinement while in conventional road heavy compaction is essential to gain strength. The comparison shown in fig no 4, depicts the reduction in the material required for the construction of MCR and Conventional road, ls.
- **Cost Comparison**
  The cost required for construction for 1km of 12m wide road is nearly 27% less than that required for the construction of a conventional road. The reduction in the cost reduction can be distinctly seen from the traditional method of construction for conventional road according to the specification laid down by IRC (Indian Road Congress) and the cost calculated as per the DSR (District Scheduled Rates) of pune, Maharashtra

Mechanical Concrete Road	Conventional Road
Cost per Km of 12 m width Road is Rs 86,82,960 /-	Cost per Km of 12 m width Road is Rs 1,18,57,200 /-
Total saving of Rs 31,74,240 /-	
26.77 % of Construction Cost Savings	

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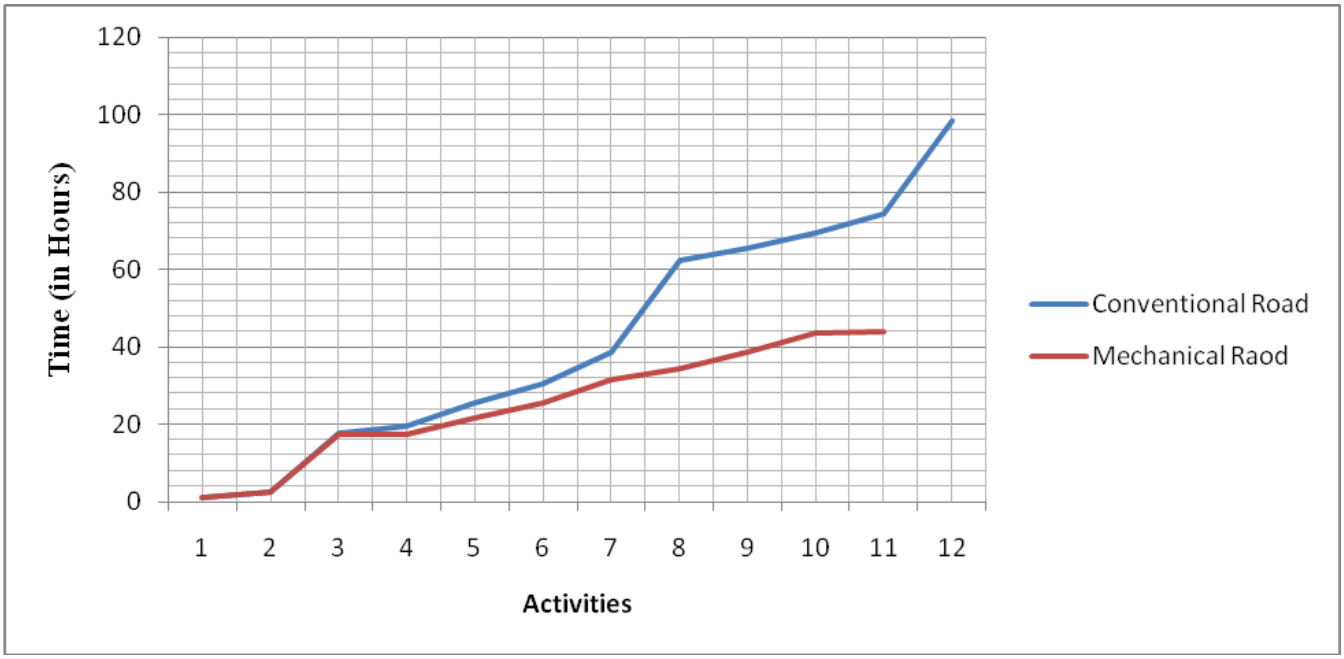
Table 1. Activity sheet for time comparison in construction of MCR and Conventional Road (in Hrs)

Conventional Road				Mechnical concrete Road			
Sr. No	Activities	Time	Cumu Time	Sr.No	Activities	Time	Cumu Time
1	Forming of alignment using total station	1	1	1	Forming of alignment using total station	1	1
2	Marking of various Length on road	1.5	2.5	2	Marking of various Length on road	1.5	2.5
3	Excavation of road upto required depth	15	17.5	3	Excavation of road upto required depth	12	17.5
4	Compaction of sub grade	2	19.5	4	Compaction of sub grade	0	17.5
5	Laying of sub base with compaction	6	25.5	5	Laying of tires	4	21.5
6	Laying of Base with compaction	5	30.5	6	Rivetting tires	4	25.5
7	Laying of WBM with compaction	8	38.5	7	Laying of filler material in tires	6	31.5
8	Hold	24	62.5	8	Laying of Prime coat	3	34.5
9	Laying of Prime coat	3	65.5	9	Laying of bituminous Mix	4	38.5
10	Laying of bituminous Mix	4	69.5	10	Compaction of top surface using roller	5	43.5
11	Compaction of top surface using roller	5	74.5	11	Ready to use	0.5	44
12	Ready to use	24	98.5				



Graph 1. Graphical representation of activity Chart.

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Fig. 4 Comparison of Material required for MCR and Conventional Road.

VI. THE REASONS WHY MECHANICAL CONCRETE DO NOT FAIL

- The principle reason Mechanical Concrete unpaved roads require less maintenance is its behaviour in the presence of water. In an unpaved road with a Mechanical Concrete base, this deterioration process is arrested at the wearing surface. Rain water can cause the compacted surface to deteriorate since it depends on particle friction for its strength. However, the water does not cause the Mechanical Concrete base to lose its lateral strength; since its strength comes directly from the cylinder material and not internal particle friction. Wearing surface maintenance is easier to perform and less costly than base maintenance.

- The next reason Mechanical Concrete® unpaved roads require less maintenance is the type of ditch behaviour it promotes. Field experience shows that unpaved roads should have a crowns and or side slopes of 1/2 inch per foot to support positive drainage. This water is either removed by ditches or through sheet drainage. When ditches are present their side-slopes created by the road-edge tend to deteriorate, and then collapse and fail over time and with use. These ditch wall failures are also a result of water reducing the internal load supporting capacity of the aggregate materials in the road. Mechanical Concrete® road bases eliminate ditch wall failures since the road-edge ditch side-slope is the face of the cylinder which is impervious to water.

- The final reason Mechanical Concrete® unpaved roads require less maintenance is the superior integration and foundation support it provides. The Mechanical Concrete base gives superior strength and economy verses the typical unpaved roadway. Its consistent angular interface integrates the wearing surface to function with the base as a unit, more effectively dispersing the loads into the sub-grade. Geometrically the tire-derived-geo-cylinder typically reduces sub-grade wheel load pressure by a factor of 2.5 to 3.0. This integration also allows rain water to be better managed, whether it is optimally compacted graded stone wearing surfaces, impregnated with resin soil stabilizers or chip-seal techniques. When properly sloped, unpaved road surfaces with a Mechanical Concrete bases have a longer useful life.

VII. CONCLUSION

The use of Mechanical Concrete in the construction of road reduces time, cost and materials required as compared to that of conventional road. It shows incredible durability due to the confinement of stone aggregates. The maintenance cost of MCR is reduced due to increased void ratio which drains off the rain water. There is heavy cost reduction in construction of MCR as compared to that of traditional roads.

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